Institution: Queen's University Belfast

Unit of Assessment: 14 Civil and Construction Engineering

a. Context

Civil Engineering is part of the School of Planning, Architecture and Civil Engineering (SPACE), which has four strong research centres; namely the Centre for Built Environment Research (CBER), the Environmental Engineering Research Centre (EERC), the Institute for Spatial and Environmental Planning and the Centre for Architecture and Construction Management. CBER and EERC form this UoA. Civil Engineering at Queens has long had an aim to produce quality research with high impact. The research ethos has placed a high emphasis on applied research and collaborating with end-users. While the unit has a regional importance in Northern Ireland the impact of research is not limited to the region but is also national and international in its reach. End-user groups include:

- Private companies who adopt the research to achieve commercial advantage, e.g. Macrete, a major producer of precast concrete for Civil Engineering;
- Authors of design codes and guides who incorporate the research findings as a means of demonstrating compliance, e.g. Highways Agency guidelines on Compressive Membrane Action;
- Public bodies that use the research in order to enable them to deliver a better service to the public, e.g. collaboration with Indian partners who have been running extensive training programmes in India on technology implementation using British Council funding.

In terms of the six types of impact identified in the REF panel criteria Civil Engineering research at Queens has had success in:

- Economic impact (eg Development of cold formed steel frames with Capital Steel Buildings, Low energy concrete with Creagh Concrete, Macrete, Bullivant and Hughes Pre-cast; Saving in cost of repair of concrete structures, worth millions of pounds, with early assessment of durability using test methods developed);
- Health impacts (eg Removal of arsenic from groundwater with National Metallurgical Laboratory, and IEMS - TATA Steel);
- Impact on practitioners (eg RILEM input to EU standards on: Low Energy Self-Compacting Concrete which encapsulates waste materials, and Near Surface Evaluation of Covercrete using Autoclam and Permit; Incorporation of Autoclam and Permit in CRIBC and Railway standards);
- Impacts on the Environment (Permeable Reactive Barrier technology).

b. Approach to impact

Within Civil Engineering research that is likely to have significant impact is promoted in a number of ways;

a) The PhD studentships which are available to new students are prioritised on the basis of quality of the research, the potential impact and plans for delivery as well as the contribution to the School's primary research themes. These studentship topics are available to prospective candidates on enquiry or online.
b) Outputs in both research and professional publications are accepted as equally important. The latter includes professional journals, books and practice manuals.
c) Secondment to a company or public body, e.g. Department for Regional Development (Nanukuttan) and Taylor and Boyd (Lulu Basheer), for periods of up to 6 months is available to further the application of research ideas and developments.
d) Sabbatical leave of up to 6 months can be taken for research purposes which include transferring research to practice.
e) Rewarding impact researchers, with promotion, support of lab and research facilities, and allocation of PhD studentships. For example, every lead researcher for the four impact cases has been rewarded in some of these ways during the REF period.
f) Senior staff mentor new staff members. Impact is emphasised in both the formal mentoring scheme as well as during co-supervision of PhD projects.

The University has one of the largest numbers of spin-out companies among UK universities. This is supported through a holding company, QUBIS Ltd and through the Research and Enterprise Directorate which, in 2009, brought together all of the University's other outward-facing research activities. Members of staff in Civil Engineering are encouraged to engage with these units where they can seek advice on the commercial application of research. They can get advice and help on patent applications, setting up spin-out companies, intellectual property rights and on securing "proof of concept" funding. For example, researchers involved in monitoring concrete performance have worked extensively with QUBIS Ltd to set up the company Amphora to manufacture and market devices for testing concrete.

In response to the large number of SMEs in the region the University has an award winning dedicated Knowledge Transfer Partnerships (KTP) team with 30 active KTPs at any one time. Members of staff in the KTP team and in Civil Engineering work together to identify opportunities and to secure funding. Since 2008 Civil Engineering has worked with 8 different companies in 10 successful Knowledge Transfer Partnerships (Northstone NI, Macrete Ireland, Horizon Renewables, Bullivant Taranto, Hughes Precast Concrete, Capital Steel, McFarland Associates, Larsen Manufacturing), and in 3 cross border FUSION partnerships (Wrights Quarry Products, Castlecool, Mainstream Renewable Power). Most of these companies are in NI and RoI, as responding to local challenges has always been an important part of the QUB Civil Engineering's impact approach. Through the additional funding members of staff are released up to half a day per week to work in/with the industrial partner. In many cases these collaborations have developed to cover wider areas of activity.

Staff in the unit have established the Ireland Brownfield Network in 2011. Its main objective is to encourage constructive dialogue and interaction amongst all those involved in the redevelopment of brownfield land in the island of Ireland. In doing so, the collective learning experiences, best practices and effective strategies can be shared to the betterment of brownfield redevelopment in Ireland. The network has a core committee of regulators, planners, lawyers, stakeholders and academics with over 100 members at present. The network specifically serves to:

- Encourage brownfield related dialogue between professionals, regulators and academics involved in the regeneration of brownfield sites throughout Ireland.
- Develop a forum where best practices in Ireland's brownfield regeneration, its assessment and its management can be highlighted, disseminated and championed.
- Encourage, support and promote the sustainable and effective regeneration of brownfield land throughout Ireland.

Civil Engineering has adopted a broad approach to ensuring that its quality research achieves the appropriate impact. The School has found, from experience, that the following ways are helpful:

1) *Starting spin-out companies, namely Amphora (www.amphorandt.com) and Sengenia (www.sengenia.com)*
2) *Working with specifying bodies eg Highways Agency, NetworkRail and Roads Service*
3) *Collaborating with world leading and large companies, e.g., Central Research Institute of Building & Construction (CRIBC, Beijing), ARUP, Aquamarine Power (ABB), and TATA Steel, for global impact*
4) *Training of a partner in new technologies, e.g. in China for concrete testing and in India for water remediation*

Full details are given in the impact case studies, explaining how these form the basis for supporting the impact and how they are achieved.

c. Strategy and plans

The School's Research Committee has a working group developing further impact strategies. It is our experience that research which has the greatest impact is that which is related to practical situations. This research, in turn, is more likely to involve experimental work at a scale and in a way which reflects reality. Therefore, to support applied research Civil Engineering has maintained a capacity for experimental research across all areas of expertise; structures, materials, environment and hydraulics, because *applied* research is crucial to achieving impact. This has

been achieved through securing external research funding, as well as the annual funding allocation to each school from the central University specifically for equipment. During 2008 to 2013, the School equipment expenditure in relation to Civil Engineering, using University internal funds, was £1.3m. It has expanded and developed its facilities with a new off-campus wave facility at Portaferry (http://news.bbc.co.uk/1/hi/northern_ireland/8626468.stm), as part of the University initiative of the £10m Institute for a Sustainable World, and new laboratories for materials research. These facilities are available for consultancy as well as research. Members of staff are enabled to provide consultancy through the School's consultancy unit QUBTest. Members of staff have used their expertise and, in some cases, the specialist facilities within the University to address technical issues such as concrete deterioration, assessment of nuclear containment structures, embankment failure etc. All administrative and accounting support is provided so that members of academic staff can concentrate on providing a first-class scientific/technical service.

The School will continue to encourage members of staff to engage in Knowledge Transfer Partnerships whereby they can apply their research knowledge in a company. There will be flexibility in the allocation of teaching duties to allow them to spend sufficient time actually in the partner company. Recognition for staff includes promotion, flexible use of the project funds, and prizes/awards within the University. This experience of industry is important to us; not just from the point of view of research impact but also for relevance to teaching.

PhD studentships are allocated to projects on the basis of a number of criteria which relate to the strategic importance of the research. The likely impact of the research is an explicit criterion used to assess strategic importance and thereby influences funding resources for studentships, equipment and consumables. During initial, differentiation, and annual reviews of PhD students, the impact of their research is a specific and important criterion. Training sessions have been specially developed for PhD students, under the University's Concordat to Support the Career Development of Researchers (http://www.qub.ac.uk/stdu). The aim is to prepare all postgraduate research students so that they can ensure that the findings of their research are exploited.

We encourage the hosting of conferences and meetings within Queens to enable us to showcase our facilities and expertise. For example, we have hosted a number of UK-China Science Bridge events attracting industrialists from China. The University has signed up to NCCPE Manifesto for Public Engagement.

d. Relationship to case studies

A niche spin-out company has enabled the products of our research to be sold and used worldwide. Case Study "Assurance of Durable Concrete" looks in greater detail at the company which makes the AutoCLAM for measuring permeability in-situ and Permit for measuring chloride migration in-situ; an illustration of economic impact.

The concept of a flat-pack arch (FlexiArch) was conceived within the University following extensive experience of arching action in concrete structures. The scale of the project to commercialise the arch was such that we needed a partner with relevant expertise. Researchers in the University teamed up with Macrete to secure funding through a KTP allowing staff to spend time working closely with the company (Case Study "£ Millions Saved").

The QUB wave power team was behind Britain's first grid-connected wave power station. All the hydrodynamic research was undertaken at Queens and currently there is a team of 30 people comprising both academic and research staff working on marine renewable research. This is the subject of Case Study "Transforming the Marine" which illustrates economic impacts.

Training partners to apply the technology, while the University maintains full ownership, is particularly applicable overseas. This approach has been used in Case Study "Removing Arsenic", an in-situ remediation technology which transforms the way arsenic is removed from groundwater. This represents clear health impact. Through EU funding and collaboration with the World Bank 6 plants have been set up in West Bengal.